Title	ANATOMICAL STUDIES ON THREE SPECIES OF DOTO (D. BELLA, D. JAPONICA AND D. PITA) FROM JAPAN (NUDIBRANCHIA : DENDRONOTOIDEA : DOTOIDAE)
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Citation	PUBLICATIONS OF THE SETO MARINE BIOLOGICAL LABORATORY (1971), 19(2-3): 73-79
Issue Date	1971-10-30
URL	http://hdl.handle.net/2433/175666
Right	
Type	Departmental Bulletin Paper
Textversion	publisher

ANATOMICAL STUDIES ON THREE SPECIES OF *DOTO* (*D. BELLA, D. JAPONICA* AND *D. PITA*) FROM JAPAN (NUDIBRANCHIA : DENDRONOTOIDEA : DOTOIDAE)[1]

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With Plates IV-V

The family Dotoidae consists of two genera *Doto* OKEN, 1815 and *Miesea* MARCUS, 1961. *Miesea* differs from *Doto* mainly in the absence of sheaths of the rhinophores (see MARCUS, 1961, p. 148). According to THIELE (1931, p. 449) and ODHNER (1936, pp. 1117-1118) the genus *Doto* (= *Idulia* LEACH, 1852) is to be subdivided into 5 sections, viz., *Doto* s.s., *Gellina* GRAY, 1850, *Iduliella* THIELE, 1931, *Caecinella* BERGH, 1870 and *Heromorpha* BERGH, 1873. During the years past of taxonomic history of *Doto* (*Doto* s.s.) a fairly large number of exotic (the Atlantic, the Mediterranean and the other districts) species have often been studied anatomically or histologically by many authors (see especially ALDER & HANCOCK, 1846; HECHT, 1895; ODHNER, 1922; and KRESS, 1968).

I myself was given, during the early spring season of 1960 and 1962, chances to collect live specimens of the two species of *Doto* (*D. bella* BABA, 1938 and *D. japonica* ODHNER, 1936) in numbers from the same *Sargassum* ground in the sea around the Mukaishima Marine Biological Station, Hiroshima University, and those species were taken as the main material of my study from the viewpoint of comparative anatomy. I take this opportunity to express my sincere thanks to Dr. Akihiko INABA, the director of the said Biological Station, who afforded me facilities for studying there.

The present paper comprises also an anatomical account of *Doto pita* MARCUS, 1955 which has so far been known from Brazilian and Florida waters and is recorded here as new to Japan. My thanks are due to some of my friends, viz., Messrs. Iwao HAMATANI, Kinzo MATSUBAYASHI and Takeo ABE, who generously provided me with the data of their specimens of *D. pita* in question.

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Publ. Seto Mar. Biol. Lab., XIX (2/3), 73-79, 1971. (Article 7)

1. *Doto (Doto) bella* BABA, 1938

(Japanese name: Kogane-matsukasa-umiushi)

Doto bella BABA, 1938, pp. 132-133, fig. 3. — Izu.

Doto (Doto) bella: BABA, 1949, pp. 94-95, 172, pl. 39, fig. 138, text-fig. 118. — Sagami Bay; ABE, 1964, pp. 60-61, pl. 30, fig. 105. — Toyama Bay and the vicinities; INABA & SAIKI, 1967, p. 10, pl. 2, figs. 4-5 (chromosome number).

In Japan this species is distributed on the Pacific coasts (Sagami Bay; Izu; Kii; the Inland Sea of Seto; and Amakusa) and on the coasts of the Japan Sea (Sado Is.; Toyama Bay; Noto Peninsula; and Tsuruga Bay). The following accounts refer to the specimens obtained from Mukaishima, the Inland Sea of Seto.

As usual, part of the animals were fixed by the BOUIN's fluid and prepared in serial sections stained by DELAFIELD's haematoxylin and eosin. They are listed below:

Sp. Nos. 1-3. Mukaishima, the Inland Sea of Seto, March 13, 1960. (H.S.)

Sp. No. 4. Mukaishima, the Inland Sea of Seto, March 13, 1960. (T.S.)

Sp. No. 5. Mukaishima, the Inland Sea of Seto, March 13, 1960. (L.S.)

External body form: The length of animals is usually 5-10 mm, and the papillae set on each back margin vary in number from 5 to 7 with age. The largest papillae are provided with 4 circlets of globose tubercles which are arranged 4-5 in each circlet. No gill is issued from any of these papillae. The margin of the rhinophorial sheath is slightly undulating. The genital orifices, anus and nephroproct are situated at the usual positions in the genus. The upper surface of the body is entirely smooth.

Colour: The general ground-colour of the body is faintly yellowish white. On the present animals an ochre yellow hue of the liver diverticula within the papillae shines through the translucent integument. The subepithelial layer of melanin pigments varies in thickness from specimen to specimen. Usually such pigments are distributed in irregular mottles over the head between the rhinophores, back and sides. It may be very scarce on some specimens, while extremely rich on others. The rhinophorial club is opaque white distally and tinted with black at about its half way. Always there is an apical spot of melanin black on each of the papillar tubercles.

Internal morphology: The pharynx inclusive of its masticatory organs is greatly reduced in size and structure as was previously pointed out by ALDER & HANCOCK (1846, fam. 3, pl. 4). The jaw-plates are shell-shaped, membraneous and destitute of denticulations on their edge. The radular formula is about 70-80 × 0.1.0. Each tooth is provided with 2-3 lateral denticles. The paired salivary glands are long and band-like. There are two oral glands (= ptyaline glands; see also glandes salivaires prébulbaires of HECHT, 1895, pl. 3, fig. 39) opening to the floor of the oral tube separately. Of these, the upper one is larger than the lower, and each is accompanied by gigantic gland cells on the surface of the vesicular portion. The liver system consists of right, left anterior and left posterior livers. The ventral position of the left posterior liver to the gonad was primarily mentioned by ALDER & HANCOCK in 1846 (fam. 3, pl. 4).

The liver diverticulum within the papilla is branching racemously. The fresh liver appears to consist of two sorts of cells, the one being loaded with yellow granules and the other with colourless ones. The rectum is very short and the anus is interhepatic in position. The kidney is an elongated sac which lies mid-dorsally on the length of the gonad. The nephroproct opens at the inner base of the anal papilla. The general structure of the genital system in this species does not differ significantly from that of the usual members of *Doto* (e.g., *D. divae* MARCUS & MARCUS, 1960 from Virginia Key, etc.). The vas deferens forms a prostate on its proximal half. The penis is conical and unarmed. The spermatocyst leading from the vagina is connected with the inner oviduct.

2. *Doto (Doto) japonica* ODHNER, 1936

(Japanese name: Matsukasa-umiushi)

Doto japonica ODHNER, 1936, pp. 1121-1122, pl. 1, figs. 11-16, text-fig. 47. — Sagami Bay; BABA, 1937, p. 327 (list only).

Doto (Doto) japonica: BABA, 1949, pp. 94, 171, pl. 39, fig. 137, text-fig. 117. — Sagami Bay; ABE, 1964, p. 60, pl. 30, fig. 104, text-fig. 25. — Toyama Bay and the vicinities.

This species ranges also very widely on the Pacific coasts (from Sagami Bay to Amakusa) and the coasts of the Japan Sea (from Sado Is. to Tsuruga Bay), being the first species of *Doto* recorded in Japan. The description given below is based on the specimens collected at Mukaishima, the Inland Sea of Seto.

External body form: The animals are usually 6-10 mm long and bear 6-8 papillae on each side of the back. The largest papillae consist each of 4-5 circlets of globose tubercles which are aranged 4-6 in each circlet. The present species is distinguished from *Doto bella* by the formation of a gill (pseudobranchium) on the inner base of respective papillae. The margin of the rhinophorial sheath is slightly wavy. The back and sides are smooth.

Colour: This species may easily be distinguished from *Doto bella* by the orange yellow or orange red hue possessed by the papillar diverticula of the liver. As is the case in *D. bella* the thickness of melanin pigments is very remarkable on the back and sides in some individuals but less so in others. The general integument of the body is faintly yellowish white in ground-colour. The rhinophorial club is whitish throughout its length. The tubercles of the papillae are tipped with black.

Internal morphology: There are seemingly no marked differences between *Doto japonica* and *D. bella* in the gross anatomy of the alimentary and excretory systems. The radular formula taken from a single specimen of *D. japonica* is about $100 \times 0.1.0$, and each tooth shows 2-3 flanking denticles. Again, *D. japonica* agrees with *D. bella* in the general aspects of the genitalia save that the penis in the former is much more elongated and thinner than that of the latter.

3. *Doto* (*Doto*) *pita* MARCUS, 1955

(Japanese name: Hiiragi-umiushi)

Doto pita MARCUS, 1955, pp. 169-170, figs. 223-225. — Brazil; MARCUS, 1957, p. 455, figs. 175-179. — Brazil; MARCUS & MARCUS, 1960, p. 164, fig. 53. — Virginia Key; MARCUS & MARCUS, 1963, p. 38. — W. Indies.

Distribution: Brazil; West Indies; Florida, Miami and Virginia Key.

A series of specimens of this species have been collected from several locations of Japan: (1) Tannowa, Osaka Bay (Mr. I. HAMATANI, collector); (2) Saigazaki, Kii (Mr. I. HAMATANI, collector); (3) Mukaishima, the Inland Sea of Seto; (4) Nomo near Nagasaki (Mr. K. MATSUBAYASHI, collector); and Toyama Bay, the Japan Sea (Mr. T. ABE, collector). The description in this paper is based mostly on the live specimens obtained in March of 1960 and 1962 from the vicinity of the Mukaishima Marine Biological Station, the fixed and sectioned specimens are shown below:

Sp. No. 6. Saigazaki, Kii, May 14, 1961. (H.S.)
Sp. No. 7. Saigazaki, Kii, May 14, 1961. (T.S.)
Sp. No. 8. Saigazaki, Kii, May 14, 1961. (L.S.)

The account of the radula is due to one of the specimens from Tannowa, Osaka Bay.

External body form: The body is small, being up to 4 mm long. The dorso-lateral papillae are usually in 5 pairs. As stated previously by MARCUS (1955) on his type specimens of the species, each papilla is scattered irregularly with bluntly pointed tubercles that never form circlets. No gill is found on any of papillae. The rest of the body surface is smooth.

Colour: The body is faintly yellowish white with traces of short, dark brown striations irregularly disposed on the head, back and sides. The liver diverticulum within the papilla is greyish white. The papillar tubercles are each marked with an opaque white spot which corresponds to the large defensive gland cell formed within. The rhinophore is white with opaque white dots towards the tip. The sole is colourless.

Internal morphology: The radula formula is about $105 \times 0.1.0$. Each tooth is flanked by 1-2 denticles. The main canal of the left posterior liver lies completely ventral to the gonad in the median line. The composition of the main part of the genital system in my specimens agrees mostly with that shown by MARCUS (1957) on his Brazilian specimens. The ovarian follicles are separated from testes (see also MARCUS & MARCUS, 1967, p. 107, *Doto pita*).

Summary

1. Three species of *Doto* of Japan are studied anatomically. They are: (1) *Doto bella* BABA, 1938; (2) *D. japonica* ODHNER, 1936; and (3) *D. pita* MARCUS, 1955. The occurrence of the last one, originally known from Brazil, is a new record in Japan.

2. A brief comparison of the features between those three species is made below mainly after the key presented by ODHNER (1936, pp. 1119-1121) for the classification of *Doto*.

(i) *Doto bella* (ODHNER's key: group I, subgroup A): Papillae in 5-7 pairs. No gills. Papillar tubercles, set in circlets, are marked with black apical spots. Liver diverticula within the papillae ochre yellow. Back and sides pigmented black. Penis short conical.

(ii) *Doto japonica* (ODHNER's key: group I, subgroup C): Papillae in 6 (–11) pairs. Each papilla with a gill. Papillar tubercles as stated for *D. bella*. Liver diverticula within the papillae orange yellow or orange red. Black pigment on back and sides. Penis exceedingly elongated.

(iii) *Doto pita* (ODHNER's key: group II, subgroup B): Papillae in 5 (–6) pairs. No gills. Papillar tubercles marked with white apical spots corresponding to defensive gland cells. These tubercles are not set in regular circlets. Colour pale with traces of dark striations on back and sides. Penis short conical.

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EXPLANATION OF PLATES IV-V

Plate IV

Figs. 1-10. *Doto bella* BABA

Fig. 1. Living animal crawling actively. Total length 10 mm (Mukaishima, Mar. 13, 1960). a. rhinophore, b. rhinophorial sheath, c. head-veil, d. nephroproct, e. anus, f. defensive gland cells, g. isolated liver cell with yellow granules, h. isolated liver cell with colourless granules.

Fig. 2. Ventral view of the anterior part of the same animal shown in Fig. 1. a. mouth.

Fig. 3. Vertical section of the rhinophore (a) retracted within a rhinophorial sheath (×20). Material: Sp. No. 3.

Fig. 4. Vertical section of a papillar tubercle (×65). Material: Sp. No. 4. a. "lime cells", b. defensive gland cells, c. "special cells", d. liver diverticulum.

Figs. 5a-5b. Radular teeth (×400) of a specimen collected from Mukaishima on Mar. 13, 1960. 5a. A tooth from the distal end of the radula; 5b. A tooth from the proximal end of the same radula.

Fig. 6. Digestive system, diagrammatic. Main material: Mukaishima, Mar. 22, 1962. a. pharynx, b. oral tube, c. unicellular glands, d. compound glands, e. right liver, f. male orifice, g. female orifice, h. anus, i. kidney, j. gonad, k. left posterior liver, l. left anterior liver.

Fig. 7. Details of the anterior part of the digestive system shown in Fig. 6. a. central nervous system, b. salivary gland, c. anus, d. nephroproct, e. kidney, f. stomach, g. gigantic gland cell, h. upper oral gland, i. lower oral gland, j. openings of the two oral glands.

Fig. 8. Left half of the transverse section of the head (×20) to show the location of the two (a, upper; b. lower) oral glands. Material: Sp. No. 4.

Fig. 9. Transverse section of the body at about the middle of its length (×20). Material: Sp. No. 4. a. kidney, b. branching of the liver diverticulum, c. left posterior liver, d. hermaphrodite duct, e. outer sinus, f. inner sinus.

Fig. 10. Median longitudinal section of the body (×20). Material: Sp. No. 5. a. kidney, b. gonad, c. stomach, d. heart, e. reno-pericardial canal, f. rectum, g. right liver, h. penis within a penial sac, i. spermatocyst, j. inner oviduct, k. albumen gland, l. mucous gland, m. left posterior liver, n. papilla.

Plate V

Fig. 1. *Doto bella* BABA; Figs. 2-6. *Doto japonica* ODHNER; Figs. 7-11. *Doto pita* MARCUS

Fig. 1. Genital organs from above. Main material: Mukaishima, Mar. 22, 1962. a. penis, b. vagina, c. outer oviduct, d. male orifice, e. female orifice, f. spermatocyst, g. mucous gland, h. albumen gland, i. inner oviduct, j. ampulla, k. prostatic part of vas deferens, l. muscular part of vas deferens.

Fig. 2. Living animal fully extended (Mukaishima, Mar. 13, 1960). Total length 10 mm. a. gill, b. anus, c. nephroproct.

Fig. 3. Two radular teeth (×250) of a specimen collected from Mukaishima on Mar. 22, 1962.

Fig. 4. Genital organs from above. Main material: Mukaishima, Mar. 22, 1962. a. salivary gland, b. penis, c. vagina, d. outer oviduct, e. spermatocyst, f. ampulla, g. upper oral gland, h. lower oral gland.

Fig. 5. Detail of the penis (a) shown in Fig. 4.

Fig. 6. Transverse section of the kidney (×25). Material: Mukaishima, Mar. 22, 1962. a. main canal, b. concretion, c. lateral expansions.

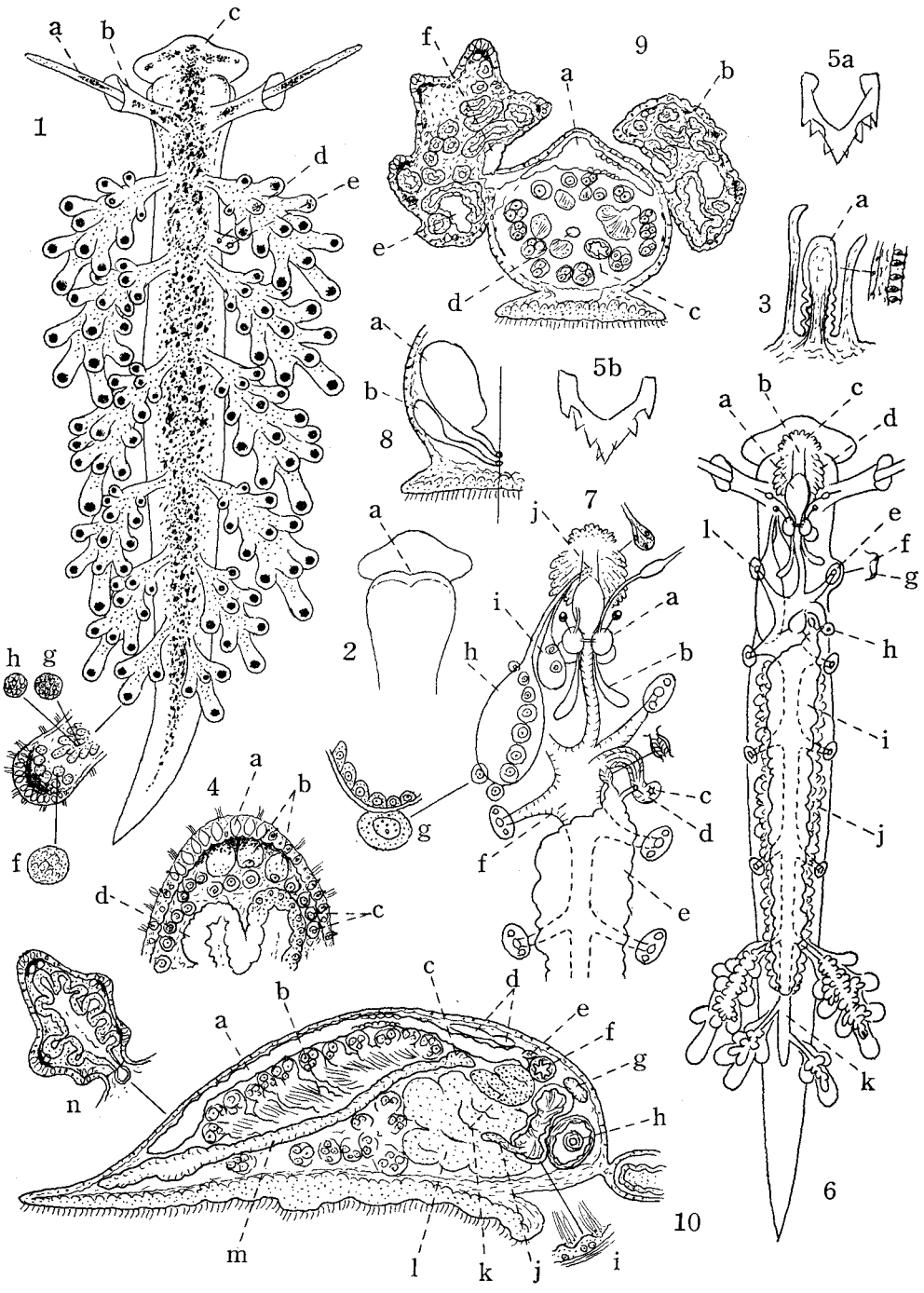
Fig. 7. Living animal in an extended state (Mukaishima, Mar. 13, 1960). Length 4 mm. a. defensive gland.

Fig. 8. Two radular teeth (×650) of a specimen collected from Tannowa, Osaka Bay on Mar. 13, 1951.

Fig. 9. Genital organs from above. Material: Sp. No. 6. a. spermatocyst, b. penis, c. vagina, d. outer oviduct, e. ampulla, f. prostatic part of vas deferens.

Fig. 10. Transverse section of the body at about the middle of its length (×25). Material: Sp. No. 7. a. kidney, b. testis, c. main canal of the left posterior liver, d. hermaphrodite duct.

Fig. 11. Vertical section of a papillar tubercle (×85). Material: Sp. No. 7. a. defensive gland.



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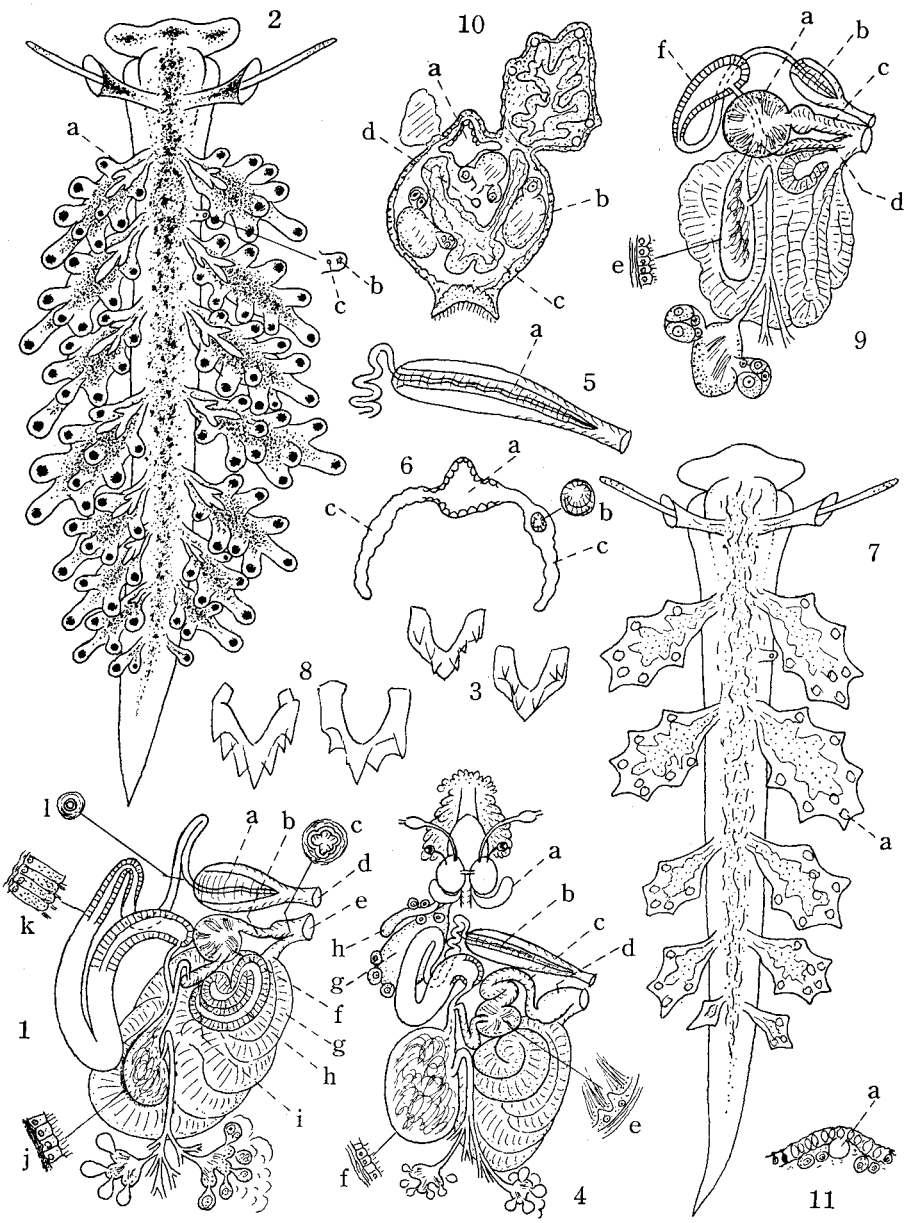

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